

# Lesson 3

## Earth System Conditions and the Natural Step Framework

### FOCUS

To explore the consequences of, and the increased demand put on, ecosystem services. To introduce students to the framework for creating a sustainable future (developed by The Natural Step) and have them explore strategies for sustainability.

### CONCEPTS

- Consumer and industry demand for products and energy is depleting resources and consequently reducing ecosystem services.
- Planet Earth's sustainability depends on working with Earth system conditions rather than against them.
- Humans can create sustainable societies by practicing the following "winning principles," or strategies, for sustainability:



Societies do not subject nature to continually increasing concentrations of substances taken from the Earth's crust.



Societies do not produce substances that build up and "overwhelm" nature's ability to cope with them.



Individuals do not physically damage nature faster than it can rebuild.



Human needs are met worldwide.

### LEARNING OBJECTIVES

#### Students

- review "sustainability" as the process of keeping the earth livable by preserving resources for future generations;

- review the four rules (natural laws) for sustainability (see Lesson 2) and the concepts of sustainability, matter, energy, and photosynthesis; and
- identify ecosystem services and explore how they can apply strategies for achieving sustainability to their own decision-making processes.



**PREP TIME:** 10 MIN.

Read background information

**PREP TIME:** 10 MIN.

Gather materials for demonstrations

**PREP TIME:** 15 MIN.

(if doing variation for younger students – see below)



**CLASS TIME:** 45-60 MIN.



### TEACHER TIP

If you have the time and space, conduct this lesson outdoors, or take students outdoors as a warm-up and have them identify ecosystem services on their school grounds or in their neighborhood. Consider ordering the movie TILT (if you can find it; it's an old one) or one of the films listed in the resources section of the Resource Guide to deepen students' understanding.

### ECOSYSTEM SERVICES

background

Think of yourself as a creature: what does this creature need to survive? The answer is easy – air to breathe, water to drink, food to eat, medicines for illnesses, and ozone to protect you from the sun's radiation – everything you take for granted as an animal. These "givens" are called ecosystem services. They are the combination of physical resources and biophysical processes in nature that create services on which living creatures depend. Ecosystem services carry no monetary price tag, but are worth trillions of dollars annually.



### Subject Areas:

Science



Social Studies



Economics



Citizenship



### Skills:



Deductive and inductive reasoning, brainstorming, applying new knowledge to familiar situations

### Materials:



- Drawing or notebook paper
- Masking tape
- Chalkboard and chalk or whiteboard and non-toxic, dry-erase markers
- Pictures or representations of:
  1. fossil fuels
  2. CO<sub>2</sub>, CFCs
  3. deforestation, overfishing
  4. movie (optional – see Resource Guide)

### Key Vocabulary:



*Review:* sustainability, matter, energy, photosynthesis, funnel, line graph

*New:* ecosystem services

### ECOSYSTEM SERVICES *(continued)*

Ecosystem services consist of life-sustaining natural resources: for example, on a large scale,

- water cycles for replenishing and cleansing: evaporation   clouds   (condensation/gravity) rain   rivers, lakes, streams   ocean   evaporation
- biodiversity that offers the “robustness” for meeting our physical needs: food, medicine
- a system for generating topsoil and nutrients, and the process of photosynthesis for transforming matter and energy into food.

On a smaller scale,

- certain amoeba and plants in oceans, rivers, and streams that purify water
- grains, vegetables, fruits, animals for food; herbs, trees, animals that yield medicines
- earthworms and microbes that fertilize soil so that food can grow

One could think, Isn’t it great that we have just what we need on this planet? – but in fact we evolved along with the ecosystem services. If we negatively impact those services, or create change at a pace with which the environment can’t cope, then humans – and other creatures – risk losing what they need to survive. (**Source:** Conversation with George Basile, Senior Scientist, The Natural Step, San Francisco, CA. August 18, 2000)

**FOR MORE INFORMATION:** Gretchen Daily (editor) et al. (1997). Nature’s Services: Societal Dependence on Natural Ecosystems. Available at <http://www.amazon.com>.

### THE NATURAL STEP FRAMEWORK

The Natural Step Framework is a way of creating a sustainable future. It is a philosophy of developing and sharing a common framework, based on commonly understood and agreed-upon scientifically based principles, that can guide society toward a sustainable future. The framework includes three conceptual components: The Funnel, Winning Principles, and Strategies for Action.

#### The Funnel

The funnel is a metaphor for where we, as a species on this planet, are. It reflects the relationship between the supply of life-sustaining resources and demand for them.

Life-sustaining natural resources (ecosystem services) are subject to increasing pressure from human activity.

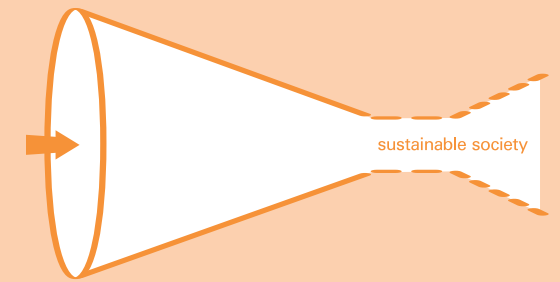
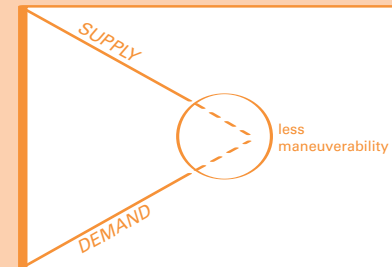
- We are losing forests and farmland.
- Species extinction is speeding up.
- We are reducing the functionality of many of our remaining resources, such as fields, forests, and oceans.
- The next wars may likely be fought over water distribution.

We are changing nature at a pace unprecedented in history; our decisions impact ecosystem services. Renewable resources are being used faster than Earth’s natural cycles can rebuild them. (**Sources:** Peter M. Vitousek et al. [1997]. Human Domination of Earth’s Ecosystems, *Science* 277:5325; Sandra Postel. [1996]. *Dividing the Waters*, Worldwatch Paper 132. Washington, DC: Worldwatch Institute.)

Because humans are animals, too, we rely on the life-sustaining benefits of ecosystem services; we don’t want to impact them negatively. As population and development increase, so does the demand for life-sustaining services. The lines on the left side of the graph (next page) can be visualized as two walls of a funnel. The “sustainability game” is played inside this funnel; all of us are in it, and our daily decisions (conscious or unconscious) have an impact. Things we never had to think about before or believe were relevant to business decisions – such as nonrenewable resources, global pollution, the loss of green space – are now shrinking the area where we can meet supply and demand. There are fewer life-supporting resources available for greater numbers of people and products. There is less and less room to make mistakes. (**Source:** Conversation with George Basile, Senior Scientist, The Natural Step, San Francisco, CA. August 18, 2000.)

### THE NATURAL STEP FRAMEWORK *(continued)*

Ecosystem Services and Life-Sustaining Resources



If we ask students, “Who demands and who needs?”, the answers are clear: I do, mom does, my school does, businesses do, etc.

The line graphs can be thought of as a “funnel,” a metaphorical image whose narrowing walls demonstrate that in the quest for good health, welfare, and economic prosperity, there is less and less “room for maneuver.” The long-term prospects of people and organizations will improve if operations are steered in a sustainable direction, towards the wide, rather than narrow, opening of the funnel. Not only are we concerned with resources, but also the combination of human impacts on these services.

Some businesses are beginning to understand that the economy is embedded in nature and not the other way around – and all of us are part of Nature. If, for example, a business chooses to manufacture products made of cotton, now the business is part of the “textile problem,” i.e., the loss of open farmland. If a business ships by truck, it becomes part of the global pollution problem and the paved-over land (loss of green space) problem.

It is important to understand what our ecosystem services are and how humans affect them.





Once we understand that, the question is, “How can we stop the ‘funnel’ from getting even smaller?”. What strategies can we use to reduce negative effects on ecosystem services?

Once we do this, then we can ask, “How can we make the ‘funnel’ bigger again?”.

#### Winning Principles

There are four conditions that must occur if societies are to be sustainable. These conditions, when honored, can keep the walls of the funnel from closing and eventually open them up again.

Humans can create sustainable societies by practicing the following “winning principles,” or strategies, for sustainability:

-  Societies do not subject nature to continually increasing concentrations of substances taken from the Earth’s crust.
-  Societies do not produce substances that build up and “overwhelm” nature’s ability to cope with them.
-  Individuals do not physically damage nature faster than it can rebuild.
-  Human needs are met worldwide.

#### Example

Think about oil. We use it in cars, machinery, plastics, and many other human-made products. How can we meet our need for oil without sacrificing or working against Earth system conditions? Below is an example of how we can revamp practices that *DO NOT* foster sustainability into practices that *DO*.

THE NATURAL STEP FRAMEWORK (continued)

Unsustainable	Sustainable
<p><b>1.</b> Oil is an organic, virtually nonrenewable, resource. We take oil out of the ground more quickly than it can be replaced. (Some say that the amount of oil we use in one year took about one million years to “make.”)</p> <p>This oil then disperses either directly, when leaks occur during production, transport, and use (the Volvo website says that ~40% of the oil that pollutes the ocean comes from cars), or indirectly, when we use oil and then throw it away or burn it (for example, in cars, buses, and oil-fired power plants).</p> <p>When crude or refined oil (oil broken down into smaller chemicals) disperses, it increases the carbon dioxide in the air and spreads throughout our waterways and oceans.</p>	<p><b>Meeting System Conditions 1 and 2</b></p> <p>A certain oil company in Sweden believes that in the long run, “We just can’t keep doing this!” The company has therefore redefined itself as an energy and chemical company rather than as an “oil” company.</p> <p>Company employees now look at the needs that oil serves and try to meet them by using biomass and renewable energy whenever they can.</p> <p>Similarly, some companies have begun programs that “lease,” rather than sell, solvents. This practice eliminates sales incentives; there is no longer any benefit to selling customers as much solvent as possible. Instead, the solvent maker gets paid in proportion to how well the solvent does its job. Solvent manufacturers pick up the old solvent, replace it with “clean” solvent, clean the old solvent, and start the cycle all over again.</p> <p>This system closes the loop, using fewer resources overall.</p>
<p><b>3.</b> When we drill for oil, we often destroy sensitive areas (for example, the coastlines of California and the Northwest United States; tundra in Alaska or Siberia). Many of the ecosystems found in these areas are very productive. They may be forested and/or serve as breeding grounds for birds and fish.</p> <p>Building refineries and their supply routes can destroy ecosystems much faster than nature can rebuild them. For example, the asphalt used to pave roads prevents regrowth and renewal of the ecosystem, and the use of oil products to support inefficient means of transport, such as vehicles that get low gas mileage, consumes a virtually nonrenewable resource at a rate exponentially faster than it took to form.</p>	<p><b>Meeting System Condition 3</b></p> <p>Humans can try to minimize the physical impact of oil drilling by finding less destructive methods; by finding oil substitutes, where possible; by deciding to build a facility to take advantage of already existing transport routes; and by restoring the biosphere to its natural state where feasible.</p>
<p><b>4.</b> Many times an oil embargo or shortage is the only incentive for finding innovative ways of conserving this resource. In “flush” times, oil prices drop and consumption may rise (the law of supply and demand). Car manufacturers and purchasers may not be as concerned about building or buying vehicles that get the best gas mileage or ones that use alternative fuels.</p>	<p><b>Meeting System Condition 4</b></p> <p>Understanding how oil is meeting people’s needs and thinking about how to meet those needs without using more and more oil is one way to practice sustainability. For example, we might use renewable energy sources and practice conservation wherever possible.</p> <p>The philosophy is “less is more”: less “stuff,” more “service.” It includes designing with materials that can be reused. It does not mean eliminating the oil business. Like the Swedish energy and chemical company, it means we figure out how best to do or get what we want by designing with the Earth in mind.</p>

For more detail and examples, see Lesson 3, Procedures, Summary.

THE NATURAL STEP FRAMEWORK (continued)

FYI: SMALL WORLD, AND GETTING SMALLER

<b>World Population</b>	<b>Estimated at 6,396,938,198<sup>1</sup></b>
Annual Growth Rate	1.31 percent
	We can expect the world’s population of 6 billion to become 12 billion by 2054 if current growth continues. Undeveloped countries tend to have a greater rate of population growth than developed countries. <sup>2</sup>
<b>U.S. Population</b>	<b>Estimated at 294,627,898<sup>1</sup></b>
Annual Growth Rate	0.9% overall
<b>Projections:</b>	
<b>Population Reference Bureau</b>	U.S. population is expected to rise 43 percent by 2050 – from 293 million today to 420 million. <sup>3</sup>

**(Sources:**

<sup>1</sup>U.S. Census Bureau, International Programs Center and U.S. Census Bureau, Population Division, <http://www.census.gov/main/www/popclock.html>

<sup>2</sup>Geography: Doubling Time and Population Growth <http://geography.about.com/library/weekly/aa051800a.htm>

<sup>3</sup>Population Connection (formerly Zero Population Growth) Factoid Archive <http://www.populationconnection.org/Factoids/>)

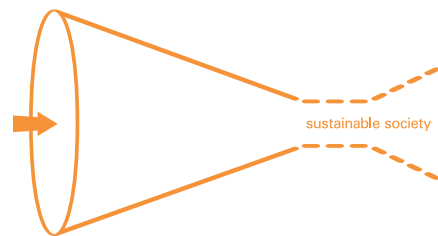
Factoids

- Over 70% of a product’s impact is determined in initial design phases. Reframing design can eliminate much of the waste from manufacturing processes. It is estimated that 99% of original materials used in the production of, or contained in, the goods made in the U.S. becomes waste within six weeks of sale; 94% of what goes into making the product is waste before it even leaves the manufacturer. (**Sources:** The Natural Step (TNS), “Design,” (<http://www.naturalstep.org/services/design.php>); The Natural Step, Presentation by George Basile, Senior Scientist, 7/28/2000. Attributed to Paul Hawken, *Factor 4*, 1997)

Procedure

Remind students of the sports analogy discussed in Lesson 2: to win a game, you obey rules and create strategies. To win the “game” of “sustainability,” people

must observe the rules of nature and develop strategies for operating successfully within Earth system conditions. Today’s activities will look more closely at “winning principles for sustainability.”



### ACTIVITY: THE FUNNEL

**Note to teachers of grades 4, 5 and 6:** See box on pg. 30 for a variation adapted for younger students on the funnel procedure. You can conduct this lesson outdoors if you wish.

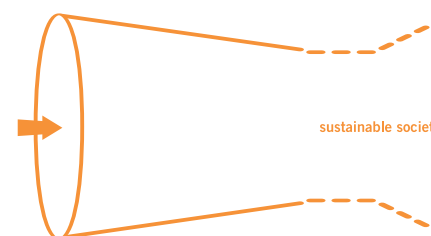
1. Review the following concepts with your students: sustainability; the four rules (natural laws) that impact sustainability (see Lesson 2)
2. Explain that photosynthesis is one example of an ecosystem service, i.e., a service that maintains the Earth in a state that can support life (see Background, above). Major categories of ecosystem services include the following (some components of each category are listed in parentheses):
  - purifying air (soil, which regulates carbon cycles; plants that exchange carbon dioxide and oxygen; tree leaves, which absorb certain pollutants, dust, and dirt, and gases such as ozone and sulfur dioxide)
  - purifying water (algae, microbes, plankton; wetlands in rural areas that protect against pesticide runoff; organisms that can break down [“eat”] sewage, oil, and other pollutants)
  - controlling soil erosion (plant roots hold soil in place; deltas, salt marshes, and barrier islands help protect shores from eroding) and keeping soils fertile (bacteria, fungi, algae, worms, ants)
  - pollinating crops and natural vegetation (bees, hummingbirds, animal waste)
  - mitigating droughts and floods (soil, plant roots, aquifers and surface streams, wetlands help control or even prevent floods; deltas, salt marshes, and barrier islands help prevent flooding; plants return water to the atmosphere, which can ease droughts)
  - detoxifying and decomposing waste (soil, microbes)
  - dispersing seeds (wind, water, animals)
  - cycling and moving nutrients (soil, which also acts as a buffer against pesticides and controls carbon, nitrogen, and sulfur cycles; photosynthesis, which helps plants convert matter into energy and food)

- controlling most potential agricultural pests (certain plants, such as zinnias, and animal/insect predators, such as spiders)
- maintaining biodiversity, which provides food and pharmaceuticals (soil to shelter seed and provide physical support for sprouting and maturing, mold for penicillin, aloe for burns, etc.)
- protecting Earth from harmful ultraviolet rays (atmospheric ozone)
- partially stabilizing climate or moderating weather extremes and their impacts (forests provide shade and cooling or insulation, depending on season; transpiration from tree leaves in the morning causes thunderstorms in the afternoon, which limits moisture loss and cools surface temperatures)
- providing aesthetic beauty that lifts the human spirit (natural features of the Earth and inhabitants of its various ecosystems; rivers that provide recreation, such as whitewater rafting or canoeing)

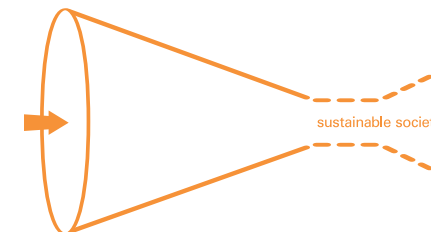
Photosynthesis – the process by which plants use the sun’s energy, chlorophyll, water, and carbon dioxide to make food – is an example of an ecosystem service that also purifies our atmosphere. (**Source:** Gretchen C. Dailey et al. [1997, Spring]. Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems. Washington, DC: Environmental Protection Agency Office of Water. [Online]. Available at <http://www.epa.gov/OWOW/watershed/wacademy/acad2000/ecosyst.html>)

3. Discuss the idea of a line graph, and how it can be used to show decreases or increases in things that can be counted or measured. Draw the line graph of the sustainability “funnel” on the board (see Background). Ask students to interpret what is happening as population and the demand for products increase. (You may wish to share population statistics [see Background section] with students, and apply this information to the “Demand” or “Need” line; or you may wish to ask students who needs these ecosystem services – and list these answers alongside the demand line).
4. Review the concept of a funnel with students. Ask students to imagine the left side of the line graph as a funnel, a “metaphor” for the idea of how as demand increases, ecosystem services diminish.

5. Have each student label a sheet of paper “Sustainability Funnel” and draw that funnel on one third of his/her paper. In it, have students individually list all the ecosystem services that they can think of. Write these on the board and discuss each one with the class. Group them into major categories. **Variation:** Take students outdoors and have them identify ecosystem services on the school grounds or in the neighborhood.
6. Talk about how our “needs” – our demands for products (matter) and energy – “squeeze” the funnel until decision-makers – businesses, governments, consumers – have less and less room to make a mistake about how or how many resources are used. (Or use this analogy: Suppose there are 200 tickets for a Back Street Boys concert at the Arena. All tickets have been sold. Imagine the doors are open for two hours before the concert – members of the audience arrive at different times during these two hours, everyone can be seated as they arrive or go to the concession stand. But what if, for whatever reason, the doors open only 15 minutes before the concert? What happens to the “resources” of time, space, and concessions?)
7. When the sustainability funnel is “squeezed,” human “maneuverability” with regard to resources diminishes. There are fewer resources to go around, and the things we need to survive as creatures begin to disappear. For example, clearcutting large areas of forest and not replanting removes a great number of trees that are responsible for cleaning our air.
8. Ask students what needs to happen in order for ecosystems to continue to support life (redraw the graphs so the lines are pulled apart and parallel rather than intersecting – representing no change [no reduction] in our ecosystem services). Ask your students to list strategies that we could use to get to this point (**examples:** reuse material, use less material to start with, find alternative energy sources, replace trees). What would we have to do/change in order to stop reducing our ecosystem services? What can individuals do? What can corporations do?



9. How can we increase our room for maneuverability? Have your students come up with ideas for opening up the funnel.



10. As a class, create one large funnel with each of the three components above, listing all of the ideas that your class has for ecosystem services, strategies for maintaining our environment as it is, and ideas for increasing our maneuverability within the Earth’s system.

### SUMMARY: WINNING PRINCIPLES

In order to attain a sustainable society, certain conditions must be met. These conditions are referred to as the four Winning Principles that must be followed to keep the walls of the funnel from closing and eventually open them back up. (Connect the students’ ideas and strategies, above, with the principles for winning the game of sustainability, below. Write each principle on the board as you discuss it. Teacher: Show pictures or representations as listed in “Materials” section. Reinforce with examples, below, as needed.)

**Winning Principle #1:** Societies do not subject nature to continually increasing concentrations of substances taken from the Earth’s crust.

### Environmental Examples

- **Fossil Fuels** – Fossil Fuels (hydrocarbons) take at least a million years to form. We burn them as fuel for automobiles, electricity, etc., and reduce their functionality extremely quickly. Incidentally, “fossil water,” which is nonrenewable groundwater, supplies 75% of Saudi Arabia’s drinking water. (**Source:** V. Gornitz et al. [1997]. Global Planet, Change 14, 147. In: Peter M. Vitousek et al. [1997]. Human Domination of Earth’s Ecosystems, Science 277:5325)





**Winning Principle #2:** Societies do not produce substances that build up and “overwhelm” nature’s ability to cope with them.

There are two parts to this problem:

- 1. We are producing substances that are alien to nature.
- 2. We are producing substances that are familiar to nature, but at such rates that nature cannot cope with them. They then accumulate in our environment.

**Demonstration for Winning Principle #2**

- Give each student one pencil. Tell them that this pencil should last for one month.
- Now ask your students what would happen if they got a new pencil every day.
- How would this affect the classroom? Would the classroom environment be able to absorb these additional resources? Would the pencils continue to be used effectively (i.e., only for writing) by the students if there were too many of them?
- This analogy can also be made with paper or other degradable classroom resources.

**Discussion: Familiar to Nature**

- Sharpening pencils creates shavings. The amount of shavings produced on a “normal” day can be coped with in the class environment.
- If we multiplied the number of pencils being sharpened by 100, we are also creating 100 times the amount of shavings. How would this affect the class environment?

**Discussion: Alien to Nature**

- Have students brainstorm on a large project (e.g. – dissection, paper machier, art) that they did in the classroom. What materials did they bring into the class environment that were not usually there (alien to the environment)? How did these materials affect this environment? What adjustments did the class have to make, based upon the introduction of these new materials?

**Environmental Examples**

- *Carbon Dioxide* – (familiar to nature)The increase in carbon dioxide represents the clearest and best-documented example of how humans have altered an Earth system. Carbon dioxide is the major waste product from burning fossil fuels. The percentage of carbon dioxide has been systematically increasing in our atmosphere since we

began measuring carbon dioxide levels in the 1950s (in 1957, 315 ppm; in 1994, 362 ppm). Analysis of air bubbles taken from ice caps demonstrates that CO<sub>2</sub> concentration was more or less stable near 280 ppm for thousands of years until 1800, and then began to increase. (**Source:** D. S. Schimel et al., [editors]. In Climate Change 1994: Radiative Forcing of Climate Change, J. T. Houghton *et al.*, [editors]. Cambridge: Cambridge University Press, 1995. Cited in Peter M. Vitousek et al. [1997]. Human Domination of Earth’s Ecosystems, Science 277:5325)

- *CFCs (Chlorofluorocarbons)* – (alien to nature) CFCs are human-made chemicals. Because they were “nontoxic” to humans, they were used as coolants in refrigerators and air conditioners; they produced the “fizz” in Styrofoam™, and the propellant in aerosol sprays. Unfortunately, their inventors and users never realized how persistent or volatile they were. When CFCs reach the stratosphere, they break down the ozone layer that protects the Earth from the sun’s ultraviolet rays. CFCs have been largely banned in the U.S., but older products that used them are still around. (**Source:** Peter M. Vitousek et al. [1997]. Human Domination of Earth’s Ecosystems, Science 277:5325)
- *Plastics* – (alien to nature) Plastics are human-made chemicals that do not degrade (break down) easily. These materials are building up in our environment. It is thought that discarded plastics will continue to be a waste disposal issue “forever.”



**Winning Principle #3:** Individuals do not physically damage nature faster than it can rebuild.

**Demonstration for Winning Principle #3**

Try one of these activities and have students observe the results. Discuss the others with your class.

What would happen if you

- removed all of the desks from the classroom?
- depleted the paper supply?
- could only use half of your room?
- moved all the desks into that half of the room, but completely eliminated the chairs?
- ripped the chalkboards from the walls or barricaded the doors?

How would these situations (plus any other difficult situations) affect your class environment?

**Environmental Examples**

- *Land transformation* – Some scientists estimate that humanity has transformed 39%–50% of the Earth’s land. Though an estimate, a consequence of land transformation is that ecosystems have been fragmented. When we cut down trees for developments or for making wood products – and don’t replant – we risk removing life-supporting services, such as the intake of carbon dioxide and the production of oxygen and food (base of the food web). (**Source:** Peter M. Vitousek et al. [1997]. Human Domination of Earth’s Ecosystems, Science 277:5325)
- *Fishing practices* – By using advanced technology, humans are able to catch more fish in less time. As of 1995, 22% of marine fisheries were overexploited or already depleted. Many fisheries are focused on the top predators, whose removal can alter marine ecosystems. (**Source:** Peter M. Vitousek et al. [1997]. Human Domination of Earth’s Ecosystems, Science 277:5325)
- *Habitat destruction* –It is estimated that 99% of all species that ever existed are now extinct; today’s rates of extinction are thought to be 100 to 1000 times those before humanity’s dominance of the Earth. Land transformation has caused locally adapted populations of species to disappear. A disproportionate loss of large mammals (due to hunting) has changed the dynamics of ecosystems in which they resided. (**Sources:** J. H. Lawton and R. M. May [editors]. [1995]. Extinction Rates. Oxford: Oxford University Press; S. L. Pimm, *et al.* [1995]. Science 269, 347. R. Dirzo and A. Miranda, in Plant-Animal Interactions; P.W. Price et al. [editors]. New York, Wiley Interscience, 1991. Cited in Peter M. Vitousek et al. [1997]. Human Domination of Earth’s Ecosystems, Science 277:5325)



**Winning Principle #4:** Human needs are met worldwide.

**Demonstration for Winning Principle #4**

- Place students in groups of 4. Have each student in each group choose a number 1 through 4. (Each student in the group must have a different number.)
  - ... Student #1 in each group receives one piece of paper. The student does not receive a pencil and will not be able to sit in a chair.
  - ... Student #2 in each group may sit in a chair, but will receive neither a pencil nor a piece of paper.

... Student #3 in each group will receive a pencil but no paper, and may not sit in a chair.  
... Student #4 in each group may sit in a chair and will receive both pencil and paper.

- Tell students, “Please write down your full name and address.” (Be ready for students to object!)
- Discuss problems that students are having doing this simple activity. (Resources have not been distributed equally. How does this impact their completion of the task?)

**Environmental Examples**

- The same idea applies to the Earth’s natural resources. There is a limited supply of certain resources, though not all. It has been suggested that the next wars will be fought over water. (**Source:** Sandra Postel. [1996]. Dividing the Waters, Worldwatch Paper 132. Washington, DC: Worldwatch Institute. [Online]. Available: <http://www.worldwatch.org/pubs/paper/132.html>; Peter M. Vitousek et al. [1997]. Human Domination of Earth’s Ecosystems, Science 277:5325). Focusing on issues like the environment and sustainability may be viewed as unrealistic if large numbers of people must compete for income/food/ecosystem services to stay alive – basic needs take precedence over what some see as “esoteric” principles.
- Have students research some of these resources (e.g., fresh water, food, fuel, etc.). Is it possible to distribute our natural resources equally to all who need it? What reasons can you think of to support such a policy? What reasons can you think of that would prevent such a policy from being enacted? Who should decide – and how should this be decided?

FUNNEL PROCEDURE VARIATION (for the younger students, grades 5-6)

PREP FOR PROCEDURE	
<div><div>1. Push desks to edges of room.</div><div>2. With masking tape, create a line graph (see funnel on page 26) on the floor.</div><div>3. List major categories of ecosystem services on posterboard or tag board, one per sheet. Also list decision makers (businesses, governments), and representative consumers.</div><div>4. Use a different color of posterboard or tagboard (cut in thirds or fourths) to list examples of ecosystem services, one per piece of tagboard. Keep a number of pieces blank; use these to write services students think of on their own. Also make cards listing decision makers (businesses, governments) and “general consumers.”</div><div>For examples of ecosystem services, see Procedures, #2 (see also Background section for this lesson).</div><div>5. Keep the masking tape handy. During the lesson (see box) you will use it to pull apart and extend the sides of the funnel to demonstrate an opening up, rather than a shutting down, of the balance between demand and supply of ecosystem services.</div></div>	<div><div>Photosynthesis – the process by which plants use the sun’s energy, chlorophyll, water, and carbon dioxide to make food – is an example of an ecosystem service that contributes to maintaining our atmosphere and supplies food for humans and animals to eat.</div><div>3. Ask for volunteers to represent each <i>ecosystem service category</i>. Give each volunteer a card labeled with a category.</div><div>4. Explain that each category is served by many ecosystem services. Use the cards you made to discuss examples. Ask students to think of other ecosystem services. Write them on the blank cards, one per card, and ask for volunteers, as above. (Note that some ecosystem services, like trees, are also considered resources.) <b>Variation:</b>Take students outdoors and have them identify ecosystem services on the school grounds or in the neighborhood.</div><div>5. Point out the floor graph (the “funnel”) and explain what the lines represent (see Background). Ask for the students holding categories of services to position themselves inside the funnel. Ask the students holding services to decide which category their service fits, and have them physically move to that area. (Allow 3-5 minutes.)</div></div>
PROCEDURE	
<div><div>1. Review the following concepts with your students: sustainabilitythe four rules (natural laws) that impact sustainability (see Lesson 2)</div><div>2. Explain that the fourth natural law, photosynthesis, is one example of an ecosystem service, i.e., a service that maintains the Earth in a state that can support life. For a list of major categories of ecosystem services and their components, see The Funnel Procedure, #2. on page 26.</div></div>	<div><div>6. Now ask for volunteers to represent decision makers and general consumers; have students come up, one at a time, along the sides of the funnel. After two or three come up, ask if they feel comfortable with the amount of resources and services they have in front of them to meet their needs.</div><div>7. Invite remaining students to come up to the funnel. How comfortable are the first few students now? Do they think they’re better off or worse off than before the other students joined them? What conclusions can they draw?</div></div>

PROCEDURE (continued)

<div><div>8. Tell the students, “Now suppose that in order to get to resources, a manufacturer had to remove part of the ecosystem, like trees, to mine coal – what would happen? Or if the manufacturer removed trees to make paper, and never replaced the trees? Or what if, in the manufacturing process, we dumped our waste into the river?” (As you say this, begin physically removing individuals who represent these services. For example, strip mining/clear cutting eliminates trees. . . and then remove the student who is standing in for the category the ecosystem services represent.)</div><div>9. Students will realize that soon, ecosystem services may disappear, and the Earth may not be able to sustain life.</div></div>	<div><div>10. For a sustainable future,<div>... We first need to think of how we can maintain, rather than reduce, ecosystem services (demonstrate this by pulling apart the small end of the funnel into two parallel lines of tape – and ask students to give examples of how this can be accomplished). What can individuals do? Corporations?</div><div>... We then need to think of how we can “open up” the funnel even more (demonstrate this by further pulling apart the taped lines or by suggesting moving back to the larger side – and ask students for their ideas on how to do this) for future generations.</div><div>... Summarize by connecting students’ ideas to the four winning principles (see <b>Procedure: SUMMARY.</b>)</div></div></div>
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Evaluation/Wrap-Up

Choose from the following activities:

1. The four Winning Principles (strategies) are a core part of the creation of a sustainable society. As a culminating activity, have students design a sustainable classroom (they may choose to work alone, with a partner, or in groups). What would it look like based upon the Winning Principles?

**Note to teachers:** See profile, “What One (Green) School Can Do,” on page 56.

2. Have students imagine that human beings are trying to colonize the moon and that the moon had already miraculously acquired some of the basic conditions for supporting human life, such as an atmosphere, a climate, and a physical soil structure similar to that of Earth. Which of Earth’s millions of species would need to be transported to the moon to make that sterile surface habitable? Let students research ecosystem services and have them “map” the new colony. Why did they make the choices they did? (Adapted from Gretchen C. Dailey et al. [1997, Spring]. Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems. Washington, DC: Environmental Protection Agency Office of Water. [Online]. Available at <http://www.epa.gov/OWOW/watershed/wacademy/acad2000/ecosyst.html>)

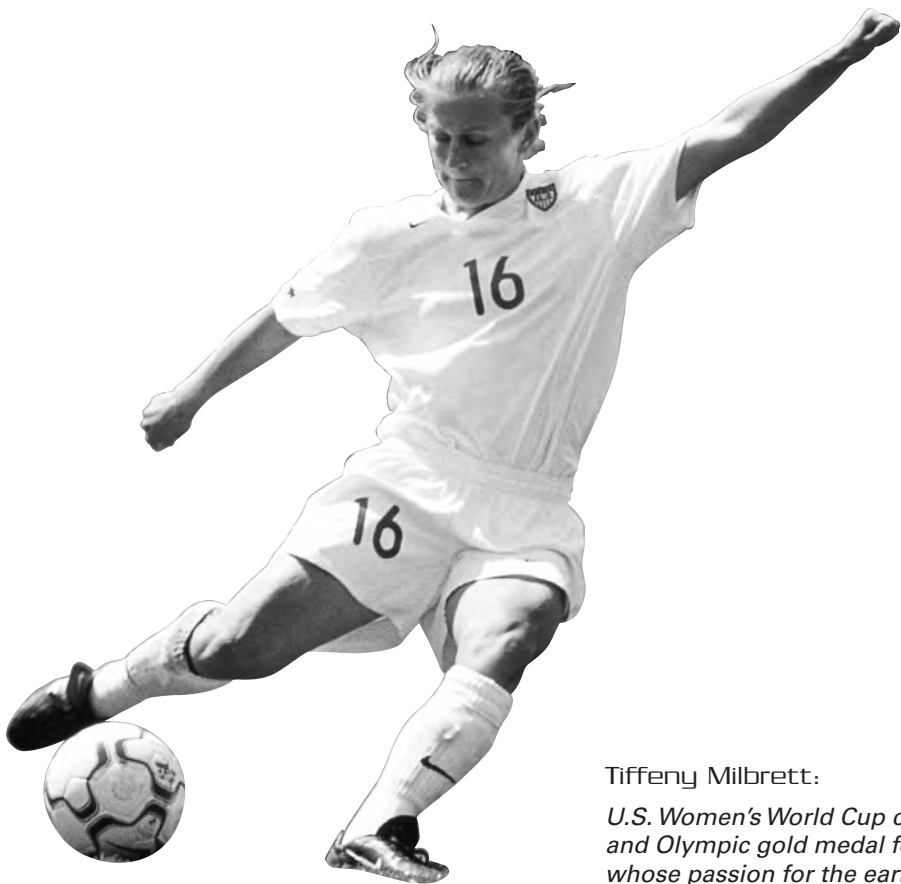
Enrichment Activity

Not all scientists who study the environment agree about the causes, the cures, or the consequences of human domination of the earth. Have students research the effects of land alteration, fishing practices, and habitat destruction. Hold a forum, in which students can debate whether or not we have an environmental crisis. For a teacher resource on conducting environmental issues forums (EIF), contact

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54-3885 Akoni Pule Hwy.  
P.O. Box 618  
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Phone (808) 889-5985  
Fax (808) 889-5987  
E-mail: [harbinger@mcn.net](mailto:harbinger@mcn.net)

Alternatively (in writing or as a class presentation), students can draw and support their own conclusions about the state of the environment (narrow the topic to one issue, such as global warming, or limit the focus to an issue in their own community) and their beliefs about sustainability.

See the Resource Guide for a list of environmentally related websites.



Tiffeny Milbrett:  
*U.S. Women's World Cup champion  
and Olympic gold medal forward  
whose passion for the earth runs deep.*